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S I L A G E A N D T H E S I L O

A N E S S A Y

IN COMPETITION FOR THE BARLOW PRIZE

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Contents

In the production of silage, the following phenomena take place. There is a rapid rise of temperature and the oxygen contained in the air that is mixed with the green forage is replaced with carbon dioxide. Later, carbon dioxide and nitrogen are given off. After an interval, the temperature moderates and then fluctuates with the surrounding conditions. The silage shrinks in bulk about one-half. During this interval, the silage has assumed a brown color, a characteristic odor, and an acid taste.

It was formerly thought that these phenomena were the result of a mild fermentation which if carried too far became putrefactive. Later, when the nature of the bacteria causing the different forms of fermentation were better understood, the phenomena were thought to be the result of the action of three kinds of ferments,-- namely: yeasts, which cause the change of sugar into alcohol and other fermentations; bacteria, which cause the formation of acid and the heating of the silage and which seemed to aid in the destructive changes, notably, those producing bad odors; and lastly, molds, which also cause putrefaction. The rise in temperature, while not fully explained, was thought not to be due to fermentation caused by yeasts, but that two or more species of bacteria were concerned in it. These were thought to be similar to those which cause

the formation of butyric acid in rancid butter. The presence of ferments which form acetic acid in vinegar and lactic acid in milk were also recognized as active in the silo and as producing much acid unless their growth was checked by the lack of oxygen. "Sweet silage," i.e. comparatively sweet silage, was produced by rapidly filling the silo and thus preventing the action of these ferments.

The Agricultural Experiment Station of Wisconsin has carried investigations a step farther, upsetting these theories. Their results are announced in their Annual Report for 1903. These results indicate that the phenomena connected with the formation of silage are not due to the action of bacteria. The bacteria require some time to develop the maximum temperature while the rise of temperature in the silage is very rapid reaching its maximum in a short time. Again, the rise in temperature and formation of normal silage occur when the bacteria have been killed, as by ether. The cause of these phenomena is assigned by the Wisconsin people to the action of the cells of the plant tissue which are still alive and carrying on their life processes. Thus, heat is developed which reaches its maximum at the start, while the cells are most vigorous. The oxygen is replaced by carbon dioxide. After the free oxygen is exhausted, the oxygen-containing compounds are attecked

The sugars are thus broken down. This gives the carbon dioxide which comes off from the silage. The free nitrogen is derived from nitrogen mixed with the air which is mixed with the green forage. Only at the death of the plant cells does this action cease.

Proof of the correctness of the theory, that silage formation is the result of the activity of plant cells, is seen when the tissues are killed and the bacteria are not, which occurs when the tissues are frozen. The rise in temperature is slower, the maximum coming much later, and the product has a bad odor, being putrefied. The conclusions of the Wisconsin Station are that bacteria have no part in the formation of good silage and that their action is entirely detrimental.

Along this same line may be mentioned an experiment conducted by the Oregon Experiment Station, which consisted in treating silage with live steam as soon as the silo was filled This destroyed the life of both the plant tissue and the bacteria. There was no rise of temperature or other action characteristic of silage formation. The corn on which the experiment was performed kept perfectly, coming out in the same condition in which it entered the silo. It was really canned corn fodder and undoubtedly a better and more nutritious product than the regular silage. It could not, however, be called

silage as it did not have the typical color, aroma or taste of silage, and did not go through the silage forming process. An approximation to the same result could be obtained by treating the fresh corn fodder with carbon dioxide gas.

The Wisconsin Station fixes the unavoidable loss occurring in silage formation at one per cent. This is due to the action of the plant cells. To keep the loss at about this point and form good silage, it is necessary to have as little air mixed with the silage as possible, and to prevent the admission of fresh air, thus checking the growth of the bacteria. The closer the silage is packed, the less air will it contain. A high silo causes greater pressure and therefore closer packing. The material should be well trodden as it is put in the silo, especially around the edges, and should be cut small and evenly mixed, so that one part is not heavier and more solid than another. This will obtain uniform packing. Smooth perpendicular walls, free from corners, facilitate even settling, and therefore close packing. To prevent the admission of fresh air, the walls and bottom must be air tight and an air-tight covering must be provided. It is necessary also that the walls be perfectly rigid for the pressure that they will be called on to withstand. The reason for this is that if the wall bulges out any, it will leave a crack between itself and

the silage along which the air will enter.

The art of building silos that are both cheap and efficient has been greatly developed by the various experiment stations which have published directions for building the different types in their bulletins. These directions may be briefly summarized as follows:

The location of the silo should be on ground that is well drained. If it is not well drained naturally, artificial drainage is necessary. When water is allowed to soften the earth under the foundations they will settle, tilting the silo and causing the walls to crack. If water is allowed to seep into the silo, it will spoil the silage with which it comes in contact.

The silo may be placed either inside or outside the barn, the general practice being to place it outside. The majority of silos are of such construction that they need no additional protection from the weather and such as are not can be made so without much additional expense. When the silo is placed within the barn, it takes up much valuable room. This is especially true of the modern round silo which generally cannot be made to fit with the interior arrangements of a barn, and thus wastes almost as much room as it occupies. This objection can be overcome in part by placing the silo in the mid-

dle of a round barn or by building it into a corner of a rectangular barn so that it rounds out the corner. If the silo is wholly within the barn, it is generally very hard to fill it on account of the difficulty experienced in conveying the material from the cutter to the top of the silo. The odor of silage in the barn is objectionable, particularly so at milking time, since it is so readily absorbed by the milk. To prevent this, the doors of the silo should be enclosed in a chute provided with a close fitting door, thus keeping the silage odor from getting out into the barn. The odor, however, can be kept out more easily if the silo is wholly outside the barn. There is really little to recommend placing the silo in the barn.

While it is better to place the silo outside the barn, it should be close to the barn and connected with it by a covered alley way. This alley way should be provided with a good smooth cement floor or with some kind of a track, since silage containing 70--80 per cent. of water is a heavy feed to handle. There should also be a chute. Both it and the covered passage way should be provided with windows. This will make it much pleasanter to get the silage out in stormy weather and prevent any of it from being blown away.

Size is the next consideration. The capacity varies as

the square of the diameter and owing to the compressibility of the silage it increases much faster than the height. This compressing also causes better silage to be made and makes it keep better. There are, however, factors which limit the size of the silo. For stability the height should not be more than twice the diameter. It is expensive, and with the usual equipment difficult, to lift the green, cut forage higher than thirty feet. A side-hill location, sinking the silo about five feet into the ground and bracing by stays will make it possible to increase this proportion of height to diameter.

The diameter is restricted by the daily amount which is to be fed. In order to prevent the silage from spoiling at the top faster than it is used a layer at least an inch and a half thick must be removed each day in winter, and a layer at least three inches thick each day in summer. If the silo is more than twenty feet in diameter, it becomes difficult to keep the surface level and to throw the silage across the silo to the opening. For this reason, it is better to build two small silos than one that is more than about twenty-two feet in diameter.

All silos require a foundation built of stone, brick or concrete. extending down to a firm footing below the frost line. For the larger silos and those of heavier construction, the foundations must be heavier and rest on a firmer footing.

The next natural question is material and method of construction. The materials used are stone, brick, wood, concrete and tile. Good silos can be made of any of these, the selection depending on the taste of the builder, the relative prices of the materials and the cost of construction. Metal silos are not used, as they are costly and the acid in the silos soon corrodes the metal. Most silos require re-inforcing, and this generally consists of iron or steel hoops.

The shape of the silo is now round almost without exception. This shape gives the largest capacity for the amount of wall and the greatest strength for the amount of material in the wall. The pressure is always outward and the same all the way round, so that there is no tendency to distort the shape of the silo. Finally there are no corners to interfere with the settling and uniform packing of the silage. Originally, the square and rectangular shapes were used. They were easy to make and fitted in nicely with the surroundings, especially if the silo was placed in the barn, as it usually was. On account of the trouble experienced with corners and bulging walls, the octagonal shape was gradually adopted, but before it became at all general the greater excellence of the round silo had swept away all other forms.

Silos are made with double and single walls. All single-

walled silos are about equally liable to let the silage freeze. The double-walled silos are successful in this respect in proportion as they have a dead air space between the two walls, and not a large proportion of this space occupied by material tying the two walls together. The heat generated in the silage tends to prevent freezing, so that only in cold climates is a double-walled silo necessary.

Stone silos are not being built much now. It is difficult to lay them in a true circle, and the re-inforcement is not put in as easily as in some other types. Also, they are hard to provide with a dead air-space. In many localities, they are much more expensive. However, when it is desired to have a silo that harmonizes with the other buildings built of stone and the first cost is no consideration, or the material is convenient, stone silos are built. They should be lined with cement, making the walls air tight and smooth on the inside. Such a silo will give good results when not subjected to severe freezing.

The brick silos are also hard to construct with the inside of uniform shape and size all the way up. They must be reinforced and plastered on the inside with cement. A double-walled silo may be constructed of brick which is fairly frost-proof. By many, the brick silo is thought to make a

better appearance than other forms which are cheaper. The wooden silos developed later than either the stone or brick. There are two types, one built upon a frame, and the other is a stave silo. Wooden silos could be set on foundations which raise the woodwork a foot or more above the ground, in order to prevent decay which would greatly shorten the life of the silo. Wooden silos look better and last longer if they are painted on the outside. The inside does not need any treatment. This material forms the least durable silo.

The wooden frame silo is built by setting upright studding about a foot apart around the foundation. As full length studding is expensive and hard to procure, the studs are often pieced. In case this is done, care should be taken to break joints and to have a difference of several feet between the elevations of the adjacent joints. Two or three layers of half inch boards are bent around horizontally and nailed into place on the inside, the joints being broken. Between the layers of boards, are placed layers of building paper.

A cement lining may be used by putting on one layer of half inch boards and lathing and plastering with five-eighths of an inch of cement. The cement gives a smooth, air-tight surface, but this lining is not very durable. The silo with cement lining needs more reinforcing than the one with the oth-

er form of lining. If the silo is to go into the barn, it needs no outside covering. But, by putting on some form of cover, it will do all right outside. This maybe thin weather boarding bent around and nailed on. In this case, the nails are going to pull through in time, letting the board spring out to be caught by the wind and blown off. It is better to put on vertical siding or metal sheeting. When this double wall is used it gives some protection against freezing. The walls must be ventilated or dampness will collect, causing rapid decay. This ventilation can be obtained by leaving an opening to the outside between the studs at the bottom and another to the inside at the top. These openings should be covered with wire netting to keep rats and mice out.

The stave silo is built of perpendicular staves two inches thick and from three to six inches wide held together by hoops very much as a barrel is held. These staves may be grooved to fit into each other but there does not seem to be any advantage in this. If the edges are left square and not beveled, the hoops in pressing the staves together are able to compress the inner edges making the silo air tight. Such staves must be nailed each to the other. The staves can be spliced as were the studs in the frame silo. When this is done, the ends of the joining staves should have slits sawed

in them, and a metal piece fitted into the two slits. An air-tight joint is thus made which also keeps the ends from springing out.

The stave silo is the cheapest form of silo, one making one for a cash outlay of sixty-five dollars. It is not as frost-proof as the frame silo and is apt to be racked by the wind if allowed to stand empty. When empty, the staves dry out and shrink, making it necessary to go over the silo and tighten up the hoops to prevent the silo from being blown down. The hoops must be held in place by some means so that they will not slip down when loose. When the silo is filled again, the staves swell and unless the hoops are loosened again, they will burst. This loosening and tightening of the hoops is one of the drawbacks to this form of silo and unless attended to the silo will be injured.

For the stave silo and the lining of the frame silo, wood which shrinks and swells very little should be used. It should be uniform, clear and straight of grain. If possible it is best to use full length staves. The woods commonly used are redwood, cypress, Oregon fir, larch, white pine and long-leafed yellow pine. This is in the order of their value for silo construction.

The concrete silo is coming into much greater use now

that the character and properties of concrete are becoming better understood. Concrete cannot be relied upon for any tensile strength, and hence the reinforcing must be designed to take all of the tensile strength without stretching enough to crack the concrete. To be successful, the concrete must be made of the best Portland cement which has been kept perfectly dry and it must be well mixed. The sand must be coarse and free from loam, clay and all vegetable matter. Very fine sand should not be used except when mixed with equal parts of coarse sand. Any clay or loam above five per cent. must be washed out.

The crushed stone or gravel constitutes the greater part of the mixture. The gravel must be free from any foreign matter. A thin layer of clay is apt to be formed over the stone, preventing the cement from taking hold. If the stone is dirty, it should be washed, but the presence of dust does no harm if it be equally distributed. The pieces of stone may be as large as two and one-half inches in diameter for foundation work and no larger than an inch and one-half for reinforced work. It is best to have a mixture of sizes, as this saves sand and cement. Generally, it is not advisable to use bank sand and gravel without screening and grading.

The water should be clean and free from strong acid or

alkalies. It is found best to place the water in a barrel near the mixing board and to put it on the pile with a bucket. This permits of more accurate measurement. The cement is most conveniently handled in the ninety-five pound package which comes in cloth bags. Concrete should be placed in position within twenty or thirty minutes after the cement is first wet. The binding power of the cement is lowered by exposure to a hot sun during the first four or five days or by anything which causes a too rapid evaporation. Cement should not be mixed when the temperature is below thirty-two degrees Fahrenheit. After being placed, good Portland cement may be frozen without being damaged much if it is not disturbed or subjected to strain until it has thawed and set naturally.

For silo construction, the best mixture is about one part cement to two parts sand and four parts stone. The mixture should be such that the sand a little more than fills the voids left in the stone and the cement a little more than fills the voids in the sand. Enough water should be used to cause the mixture to quake. It is essential that each stone and each grain of sand be coated with a layer of cement and that the mixture be uniform.

A thin stick or spade should be pushed down into the fresh concrete along the mold in order to push the larger

stones back and thus leave a uniform surface. When, after a stop, work is resumed, care must be used to get a good union between the old and new concrete. The surface of the old concrete must be thoroughly cleaned and soaked with water and then be treated with a thin layer of neat cement before the fresh concrete is put in place. The forms are best which are so arranged that the silo can be built up in sections, the forms being removed and set higher up for the next section; they should have a smooth surface and be perfectly rigid, so that the concrete will not be disturbed while setting and the inside cross sections will be the same throughout. By imbedding the reinforcing rods in concrete, the concrete protects the metal from rust. The upright rods should be placed at about the middle of the wall with the horizontal circular reinforcements outside of these. The amount of reinforcement can be best obtained from tables. It varies directly as the diameter and according to the distance from the top.

The walls may be made single or double. If they are single, they should be for common sizes of silos six inches thick at the bottom and four at the top.

If the walls are double, the inner wall should be according to the Iowa Experiment Station five and one-half inches thick and the outer wall three and one-half inches thick.

To prevent the circulation of air in the space between the walls, tarred paper is inserted, forming horizontal partitions every three and one-half feet. This double-wall silo is much harder to construct than a single-wall silo, but it affords the very best protection against freezing.

It has been charged that the concrete silo is liable to crack. This, however, is not the case if the silo has been properly constructed. It is also plain that the acid in the silage will attack the concrete, softening it and causing it to crumble. This has not been borne out in practice, but, as a protection, the inside of the silo may be treated with hot coal tar.

This form of silo seems to me to be the one that will be most extensively used in the future. It is tight. It conceals and protects its reinforcement. It is fairly cheap and very durable, and in common with all but the wooden silos is fire-proof.

Concrete blocks have been used somewhat in silo construction. They give good satisfaction if the inside is plastered with cement to make it air-tight and water-tight, and there is plenty of reinforcement to resist the bursting pressure in the silo. It does away with the molds in the monolithic structure. But the cost is somewhat higher, as finer gravel

must be used.

Another material which can be used for silo construction is clay tile. In localities where other materials are hard to get this furnishes the cheapest material. The tiles are laid into a wall which is coated smoothly inside and out with cement. The reinforcement which should be ample to take care of the entire bursting pressure should be buried in the outside coat of cement. This silo is air and water tight and well insulated from the cold. Although it has not as yet been thoroughly tested, there is no apparent reason why it should hot succeed.

The doors of the silo should be about thirty inches high and twenty inches wide. They should be placed one above the other not further apart than about three feet. Sometimes the doors are put one on top of the other, forming a continuous door. If the silo is designed to have the reinforcement carried around the chute, this continuous door is found very convenient. For the stave silo, the doors are simply sawed out of the side of the silo, being sawed at such a bevel that they will be held in place by the pressure of the silage within. For the frame silo, shoulders are left on the inside lining against which the lining of the door presses. A wooden door frame is also provided. For stone, brick, concrete and

tile silos, the doors should be moulded of concrete, thus making them as durable as the rest of the silo. Some kind of gasket should be used between the door and the frame to make the joint air-tight. This may be clay, tar paper, builders' paper or strips of felt. The doors themselves should be air-tight and smooth on the inside. There should be nothing about the doors or frames to hinder the settling of the silage.

The floor of the silo should be rat, mouse and water proof. Well puddled clay will do but a floor of four to six inches of concrete is better.

Some claim that a roof on a silo is unnecessary. However, a roof looks better and keeps the rain and snow off the silage, making the removal of the silage much pleasanter in stormy weather. Where the silage is apt to freeze at all, it is sure to freeze on the top unless the radiation of heat is checked by a roof. The roof should be ventilated enough to allow the escape of the gases given off by the silage and should contain an opening through which the green forage is introduced into the silo.

The cost of the silo varies according to the locality, being governed by the cost of the material and labor in that locality. Many firms advertise stave silos all ready to set up. Other firms go around building brick and concrete silos.

These manufactured silos as a rule give very satisfactory results. Directions are contained in agricultural papers and bulletins of experiment stations from which the farmer may build a silo or he may design one himself, having in mind the principles of the silo. However the silo is built and whatever the material of construction is, it should be remembered that a cheap silo which fails is an extravagance.

The crops which are suitable for the silo are corn, sorghum, pea vines, beet tops and pulp and the legumes. They should be cut for the silo when they have reached their full growth, and as they begin to dry out. If the crop is too watery, the silage will be excessively acid. This can be prevented by allowing the crop to wilt for awhile after cutting until the proper degree of moisture has been obtained. Unless the crop has an excess of moisture, it can be hauled in after being rained on while it is still wet. If the crop is too dry, the silage will mold. To prevent this, the material should be sprinkled with water as it is put in the silo. The forage should be cut into lengths half an inch to three quarters of an inch long. This length makes possible close packing and gives pieces which do not cut the mouths of the animals.

The cost of filling the silo can often be greatly re-

duced by properly proportioning the men and teams to the machinery. The cutter should be large enough to handle the work. Self-feeding machines are now on the market which will take the forage as fast as two men can throw it on the carrier. The cut material may be conveyed into the silo by a covered carrier or by a blower. The blower is able to put the cut forage into a higher silo but it requires more power to operate it. If there is not enough power, the pipe will choke up and trouble will begin. There should be a fourth tube conveying the forage from the end of the blower pipe to the bottom of the silo. This is necessary in order to obtain an even distribution of the heavy and light particles. Otherwise the heavy particles would fall in the centre while the lighter pieces would be whirled around the edges, causing uneven packing and producing a non-uniform feed.

The wagons should be low and flat for the green material is very heavy to handle. Corn should be cut with a corn binder while the other crops may be cut with a mowing machine and raked up.

During filling, the surface of the silage must not be left exposed for longer than two days without covering with fresh silage. The silage can be fed at once and if this is done no cover is needed. If the silage is to stand awhile, it

should be covered in some manner to exclude the air. A good way is to cover it with a cheap fine succulent material which has been run through the cutter. This should be well tramped and wet down with about one gallon of water to the square foot. The rapid decay forms a dense air-tight covering. Almost any material that will pack well may be used or the silage itself may be treated in this way without other cover.

Corn is the crop best suited for use in the silo. Its adaptation as to soil and climate is wide. It gives a heavy yield of succulent and palatable forage, cutting twelve or fifteen tons per acre and sometimes as high as thirty tons per acre. This last weight, however, is composed of too large a percentage of water. A good yield will contain six thousand pounds of actual dry matter per acre. Corn, besides being the heaviest yielding crop is also the easiest to preserve in the silo. Corn silage is high in carbohydrates and low in protein, so that in feeding it feeds high in protein are necessary to balance the ration. Corn should be cut for the silo when the grains are well glazed and are beginning to dent. The variety of corn to be grown for silage is one that will mature its ears during the growing season of the particular locality and will at the same time give a large yield of stalks and ears per acre. Corn for the silo may be planted a

little closer than when it is grown for grain.

When the corn fodder is cured and kept in the dry state, it is not nearly as palatable as silage and the coarser parts are not eaten clean. The fodder requires a great deal of storage room or if left exposed rapidly deteriorates. If the forage has been partly frozen and is then put in the silo, there will still be enough live cells left in the stalks to form good silage, but if it has been completely frozen, it is a waste of time to place it in the silo, as silage will not be formed.

Sorghum has silage-producing qualities very similar to corn. It does not produce as much per acre, but is better suited to a semi-arid climate.

Peavines are some times stored in the silo, as a by-product of a canning factory. Their hollow stems hold considerable air which makes the silage hard to preserve, and they are altogether too succulent to form good silage. However, this is the best way to utilize the by-product.

Beet tops and pulp are two by-products of the beet sugar industry which by the help of the silo can be prevented from going to waste.

Legumes are high in protein and hence afford a valuable feed able to take the place of part of the proteinaceous

grain ration. But, without exception, all legumes are hard to make into hay requiring careful curing and handling. With the best of care a large per cent. of the best parts are broken off and lost. Also legumes are greatly injured if allowed to become wet after they have been partly cured. This would seem to indicate that with the help of the silo the crop would be most efficiently handled. Nothing would be broken off or lost and there would be no danger of injury by rain. Yet the legumes are an uncertain crop for silage, being subject, particularly when very succulent, to anaerobic bacterial fermentation. These bacteria are able to live away from free oxygen, obtaining all they need from oxygen contained in oxygen compounds. They cause decay and are not affected by the silage-forming process. It may be that the Oregon method of treating the green forage with live steam or some other material which destroys all life in the forage will some day be successfully applied to this variety of forage. It has been found successful to put legumes in the silo mixed with equal parts of corn. This mixture gives a silage much richer in protein and it keeps very well.

The other forage crops and cereals commonly grown are not suitable for the silo. They have hollow stems and are too succulent; they are easier to harvest otherwise and do not

give as large a yield per acre as does corn.

Silage is suited especially to cattle and sheep; pigs do not do well on silage alone, it serving only as a maintenance ration. A little silage tends to keep the digestion of pigs in good condition. Although horses can learn to eat silage and it keeps them in good condition, they cannot do much work on it alone, and if doing heavy work should not have much silage in their ration, as they are not able then to digest much coarse forage. Animals that chew the cud are better qualified to digest a bulky feed to advantage, getting more energy from in excess of that needed for digestion. Moreover, these animals seem to feel the need of a succulent food more than other animals.

With sheep, silage is especially valuable for breeding ewes. Sheep eat so little silage, that, as a rule, silage is not put up for them except when it is being put up for cattle also.

In regard to the value of silage for beef production, there is a difference of opinion. The cause of this seems to be that in the test carried on no allowance was mmade for the fact that silage-fed steers need more shelter than do corn-fed steers. Humphrey Jones says in Wallace's Farmer after four years of experience with beef cattle that the gains dur-

ing feeding periods of four to seven months have been from 1.75 to 2.50 pounds per day. The cattle finished much more evenly and the hair and general appearance were much better than those of corn-fed animals. Fewer animals got "off feed" and the cost of gain was much less.

Humphrey Jones found that silage kept the system cool and hence the animal had less surplus heat to get rid of. For this reason, they did not do as well with the same exposure and on which the corn-fed animals thrived best. He fed per day for a thousand pound animal fifty pounds of silage on which was sprinkled five pounds of cottonseed meal. In addition to this, there were eaten six or seven pounds of clover hay. His experiences are published in the Iowa Year Book for 1905.

The silo has been developed for the needs of the dairy cow and is especially adapted to her needs. A succulent feed of some sort is necessary in order to secure a full flow of milk. Roots and pumpkins were formerly used for this feed in the winter. However, they do not yield as heavily as corn and are so difficult and expensive to harvest that they make the cost of winter milk much greater than summer milk. Silage on the other hand, is found to be economical to feed the year round, the cows not being put on pasture at all.

Cows will eat twenty to forty pounds of silage per day. In addition, to this, they need some dry roughage and some concentrates. As a corn silage is rich in carbohydrates and poor in protein, the protein must be provided in the dry roughage or in the concentrates. If alfalfa or clover hay is to be had, it supplies a good part of the protein, enabling cheaper concentrates to be used. Cows are at times inclined to choke on dry meal, but if the latter is sprinkled on the silage, there will be practically no danger from this source. It is dangerous to feed frozen silage to cows. If the silage is frozen, it should be thawed either by setting it in the barn or by mixing it with unfrozen silage. It should be fed as soon as thawed as it will not keep. Objection is sometimes made to silage in the dairy on the ground that it taints the milk, but if the silage is good and there is none in the stable during milking time, there will be no tain noticeable. The Illinois Experiment Station has conducted some tests along this line which indicate that when good silage is used the resulting milk is slightly preferable to milk produced from other feeds. Out of 372 comparisons between silage and non-silage milk, sixty per cent. were in favor of the silage milk, twenty-nine per cent. preferred the non-silage milk and eleven per cent. could not detect any difference.

The value of silage has often been greatly over-stated by its too ardent advocates. It is not better than green forage, is not the best and cheapest feed for all animals and under all conditions, and is not a complete feed in itself for any animal, since it is not perfectly balanced and has too much bulk. Naturally, it was impossible to do all that the enthusiasts promised.

On the other hand, through ignorance of principles and proper conditions for silage formation and feeding, it has not always been presented in the proper light in the tests carried on by the various experiment stations. as, for instance, when silage has been put up while too immature and too succulent and a report is sent out that silage is very low in nutritive value and in actual dry matter, and that it is very acid. or, when animals are fed silage only without any grain or dry roughage, and the report comes out that animals do not do well on silage; or, again, when silage fed steers are exposed to rough weather and do not thrive well. In this case, it is simply a question of whether the advantages accruing from feeding silage to steers instead of corn and corn fodder woud would warrant the expense of providing shelter for the animals.

However, all these mistakes have been and are being right

ed and we are getting a correct view of the true value to the farm of silage and the silo. It is generally agreed that the use of silage has the following advantages:

First, it provides a succulent, palatable food which t- keeps the digestive apparatus in good condition, the appetite keen and the blood cool.

Second, it enables the food to be stored in a smaller space and when fire-proof silos are built without any risk of fire. A ton of hay requires at least four hundred cubic feet of space in the mow, which is just about eight times the amount of space occupied by a ton of silage. Hence while a ton of hay contains one thousand six hundred and eighty pounds of dry matter, the same space in the silo contains just twice as much. There are also two and one-third times as much digestible nutrients in the silo as in the same space in the mow. The comparison of silage to corn fodder is even greater.

Third, when the silo is used, crops can often be harvested to better advantage. The land is cleared more quickly and earlier so that it can be prepared for the succeeding crop sooner. The crop can be gathered during and after weather which would not permit of its being harvested by the other methods, thus often saving a crop that would otherwise have been lost. It costs less in the case of corn to haul the

comparatively heavy green forage to the silo, cut it and put it in the silo than it does to haul in the corn and fodder, husk and grind the corn, and shred and store the fodder. The Illinois Station found that the cost of filling the silo varied from forty to sixty cents per ton, averaging fifty-six cents. The fact that the work is all done in a short time may or may not be an advantage.

Fourth, the silo can be located so that the silage can be fed more conveniently than any other form of roughage.

Fifth, silage will help out the pasture or where intensive farming is practiced will replace it entirely. As compared with soiling crops, it is much more convenient to gather the entire crop when it is at the best stage of maturity and when the weather is right, than to keep the help necessary to cut and gather each day's forage rain or shine.

However, the silo is not desirable in every locality, as where few cattle are kept, where soiling crops or pasture are available the year around, or where land is cheap and building costly.

The development of the silo covers a long period. In Egypt, in the time of Pliny, grain was stored in air tight receptacles in which the oxygen of the air was replaced with carbon dioxide by the cells in the tissue of the grain. The

grain would keep thus for over one hundred years. Nothing was known of the principles of silage formation.

The first mention of the application of the art to the preservation of forage comes from Italy where we find the farmers packing wilted leaves in casks which were then covered with sand to protect them from the air. This was before 1786. Their work does not seem to have had much bearing upon the development of the silo.

Long before 1843, green forage was preserved in Germany, the product being known as "sour" or "brown" hay. It was preserved in pits or silos, lined with wood and puddled clay. Salt was mixed with the green forage at the rate of one pound of salt to each hundred pounds of forage. The French developed this method by putting a masonry lining in the pit and late later extending the silo more or less above the ground. They also left out the salt. In 1877, M. Auguste Goffart, a gentlemen farmer of France, after a series of experiments with silos, published a book entitled "The Manual of the Culture and Siloing of Maize." His work did a great deal toward the wider introduction of the silo. In recognition of his services, his government awarded him the Cross of the Legion of Honor.

The silo at this stage of its develdpment was brought to

America, the first being built in 1875 by Dr. Manly Miles of the Michigan Experiment Station. In America, the development of the silo was very rapid, due mainly to the work of the different experimentsstations, situated in states prominent in the dairy industry. A large part of the work, however, was done by individuals for the more progressive and intelligent American dairymen built silos, each one experimenting on some particular feature that seemed to him to have special value. The Experiment Stations, in addition to doing original work of their own collected the results of the silo experiments of these individuals, and published and distributed in bulletin form what had thus been learned.

Goffart's silo was square of heavy masonry construction and its system called for heavy weights on top of the silage. American ingenuity developed the lighter and cheaper round reinforced silo built almost wholly above ground, thus reducing the weight and cost of the walls and increasing the efficiency. The increased height removed the necessity for wei weights to be put on top of the silage and decreased the proportion borne by the spoiled silage on top to the whole mass. The cost of the silo was also greatly reduced by introducing wood into its construction. The present increasing scarcity of wood together with theincreasing knowledge of the proper-

ties of concrete point to the latter as the material to be used for silo construction in the future.

The experiment stations have also carried on elaborate experiments to determine the actual economic value of silage made from different crops and used as feed for the various classes of animals, and to determine the exact nature of the changes which go on in the silo during the formation of silage, together with the principles underlying and controlling these changes. They have thus established some quite definite results which I have attempted to set forth in this essay.

The silo has now become a fixed factor in the more intensive dairy farm management and it is generally so recognized.

In compiling the material for this essay, I have drawn on the following sources:

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